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# CONTRIBUTIONS OF MUSLIM MECHANICAL ENGINEERS IN MODERN AUTOMATA (IN LIGHT OF KITĀB AL-ḤIYAL OF AL- ĠAZARĪ) A DESCRIPTIVE ANALYTICAL STUDY

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## ABSTRACT

Were the Muslims in ancient times highly proficient in mechanical engineering? Did they have a head start over the West in this field? Unfortunately, it is noticeable nowadays that Arabs and Muslims all over the world became just consumers; exploiting all technological developments of the West that are rapidly growing. Here we had to wonder whether the Arab Muslims, long ago, were on this manner. This research hypothesizes that Muslims had attained an advanced level in mechanical engineering and were the inventors of the self-moving artifacts; recently known as automata. Accordingly, this research has undertaken the mission to prove that assumption. This paper focuses on automata machines, in light of «*kitāb al-Ḥiyal*» of the Muslim engineer *al- Ġazarī*. This book -initially manuscript- included a detailed description for these machines accompanied with painted illustrations known as «miniatures». The paper begins with a preface dealing with the meaning of fine technology and automata, followed by the story of automata since antique ages and until the medieval epochs. The latter element is an indication to Muslims' contributions on mechanical engineering in general, and automata in particular. This is supported by previewing samples on automata «self-moving» machines according to the miniatures of «*kitāb al-Ḥiyal* ». This is followed by a briefed biography of the book author *al- Ġazarī* and a historical and artistic analysis for the book itself. Finally, there is a concise scientific analysis for the chosen samples of automata and their relevancy to modern machines and advanced technological industries. Conclusively, in relation to the value of «*kitāb al-Ḥiyal*» that is dated back to the 7<sup>th</sup> century AH/ 13<sup>th</sup> century AD, this research accentuated that automata machines are not a Western invention. Definitely, they are an outcome of the Golden Age of the Islamic civilization, proving their supremacy in mechanical engineering since the medieval epochs.

**KEYWORDS:** Mechanical engineering, Automata, Miniatures, Manuscript, Islamic civilization, *al- Ġazarī*, *kitāb al-Ḥiyal*.

## I. INTRODUCTION

### RESEARCH PLAN:

- I. Preface.
- II. Story of automata since antique ages and onwards .
- III. Contributions of Muslim mechanical engineers in automata.
- IV. Muslims' automata mechanisms according to miniatures of «*kitāb al-Ĥiyal*».
- V. Historical and Artistic analysis for the publication of «*kitāb al-Ĥiyal*».
- VI. Concise scientific analysis for the chosen automata mechanisms.
- VII. Conclusion.

### I. PREFACE

This research paper illuminates on Muslims' contributions in producing self-moving artifacts known as «automata». This is incorporated under the title of fine technology, recently known as mechanical engineering, referring to multiple mechanisms modeled basically for amusement, for time keeping and for diverse needs of scientists.<sup>1</sup>

Unfortunately, due to their fragile composition; few remnants of fine technology mechanisms can be tracked. Thus, their construction and operating systems had been basically extracted from iconographic sources<sup>2</sup>. Earliest information about the origins of fine technology occurs in the writings of the Roman architect *Vitruvius*<sup>3</sup>, who attributed the invention of the organ and monumental water-clock to an Egyptian engineer named *Ctesibius*, who worked in Alexandria around 300 BC<sup>4</sup>. Later achievements in fine technology had been attributed to *Philo* of Byzantium, nearly dated back to 200 BC, and *Hero* of Alexandria almost from the mid of 100 BC<sup>5</sup>.

These antique sources confirm that automaton mechanisms had been known since antique civilizations; all had produced primitive samples, almost, in the form of jointed figurines. Further phase was the Hellenic civilization to which is ascribed the success in producing real automata samples<sup>6</sup>. Nevertheless, Muslim engineers had managed to manufacture more advanced automata artifacts; the mechanism of which is still exploited in modern ones, developed by virtue of industrial evolution in the West<sup>7</sup>.

Hence, this paper espousals the idea that Muslim engineers had the priority in presenting such advanced technology to the universe. This is confirmed by the

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<sup>1</sup> DRACHMANN 1948: 63.

<sup>2</sup> HILL 1993:112-140.

<sup>3</sup> He is Marcus Vitruvius Polio; a Roman architect and engineer, who was widely famed during the 1<sup>st</sup> century BC; CECCARELLI 2014: 307-44.

<sup>4</sup> HILL 1993:112-140.

<sup>5</sup> DRACHMANN 1948: 1-197

<sup>6</sup> BERRYMAN 2003: 344-69.

<sup>7</sup> HILL 1993:122-48.

manuscripts of Muslim scientists such as *Banū Mūsā* and the Muslim engineer *al- Ġazarī*, whose works are still preserved in several libraries all over the world.

Despite such historical indications, several Western scientists are denying Muslims' favor in the emergence of modern automata. Across this research paper, the author attempts to disclaim these allegations by describing – through painted miniatures- real samples of automata mechanisms from «*kitāb al-Ĥiyal*» for the Muslim engineer *al- Ġazarī*.

Although several academic studies had dealt with the achievements of Islamic civilization in sciences as a whole, none have been conducted to shed light on Muslims' supremacy on automata. Accordingly, this research paper has the priority in conducting a concise scientific analysis; accentuating how the Muslim automata samples had paved the way to the emergence of the recent advanced counterparts. Furthermore, it illuminates how several technical applications became well-known, and are still in use by virtue of the antique automata mechanisms built by *al- Ġazarī*.

## II. STORY OF AUTOMATA SINCE ANTIQUE AGES AND ONWARDS

The story of automata is deep-rooted, since man was eager to simulate the universe through graphics and plastic arts. Ancient grotesque figurines<sup>8</sup> and idols found in burials testify on this inspiration's age-old in primitive religions. Although automata are almost renowned to have begun in the Hellenic civilization, it is clear that man managed to elaborate pictorial representations with automata long before<sup>9</sup>. It is documented that proto-automata samples in shape of dolls with joined arms and other articulated figurines were early known from the ancient Egyptian tombs of the 12<sup>th</sup> dynasty onwards<sup>10</sup>.

One of these jointed figurines among the properties of the Metropolitan museum of arts is an Egyptian small and precisely carved wood statuette, representing a wholly naked woman, with heavy shoulder-length wig [FIGURE 1]. The statuette's right hand is maintaining its propriety by covering the genital parts; however, the breasts were to be masked by the missing left arm. A simple technique had been applied; the arms were designed to be raised and so uncover the feminine genital and other charm organs. This statuette is a rare sample of proto- automaton, resembling an infrequently level of mechanical superiority in the archaeological record of the Nile Valley. According to preliminary examination, this small statuette was attributed to Egyptian middle

<sup>8</sup> The word «Grotesque» is derived from the Italian *grotteschi*; referring to the grottoes in which these decorations were found c. 1500. Such decoration was either mural or sculptural, represented in unfamiliar combined shapes, inclined to be unreal, comical and even caricature.

BARASCH 1971: 9.

<sup>9</sup> DE SOLLA PRICE 1964: 9–23

<sup>10</sup> CHAPUIS & DROZ 1958: 13–29.

kingdom, almost the 12<sup>th</sup> dynasty (ca. 1981-1802 BC). Though, due to high profession of sculpting, further examinations tended to attribute this statuette to a later date; about the 18<sup>th</sup> dynasty (ca. 1550-1295 BC). However, shortly, the 12<sup>th</sup> dynasty again had been favored.

The mechanism applied in this statuette is composed of a rotating axle introduced into the torso through a square-cut hole in the right shoulder [FIGURE 2]. This hole gives access to a large, precisely vacuum cut and a small, drilled exit hole. One end of the axle is fashioned as a tenon, where the statuette's right arm is attached. The axle's other end preserves the remnants of an identical tenon; where the missing left arm was once attached [FIGURE 3]<sup>11</sup>.

Actually, the purpose for which ancient Egyptian craftsman exploited this mechanism is still unclear. However, some historians interpreted that to be a simulation for a comic dance of the goddess «*Hathor*» to bestow pleasure on the «*Sun God*» as a ritual performance.<sup>12</sup> Conclusively, the mechanical nature of this ancient Egyptian statuette renders it a particular significance<sup>13</sup>.

A further record of automata self-moving artifacts -as numerous historians of technology stated- had been revealed in ancient Homeric literature<sup>14</sup>, which dealt with self- moving devices as a personification of their Gods<sup>15</sup>. By the beginning of the Hellenic culture, the natural exaggeration in mythology had produced the concept of simulacra with multi abilities that exceed proto-automata figurines; just talking or moving their arms. Hellenic Daedalus<sup>16</sup>, managed to imitate the flight of birds, and fashioned guarding statues that moved and walked in front of the labyrinth<sup>17</sup>. Another case is Archytas of Tarentum<sup>18</sup>, who succeeded in making a wooden flying dove functioned by counterweights and air pressure<sup>19</sup>.

From at least the 4<sup>th</sup> century AD, a growing body of techniques and ideas gathered under the label «mechanics». In Hellenistic times, mechanics had been considerably developed in theoretical and practical means as well. In advanced natural philosophy,

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<sup>11</sup> REEVES 2015: 42–61.

<sup>12</sup> SCHARFF 1927: 61.

<sup>13</sup> REEVES 2015: 42-61

<sup>14</sup> Homer is one of the most influential Hellenic authors during 9th or 8th century BC. He was presumed as the author of the Iliad and the Odyssey, two hugely influential epic poems, FOWLER 2004: 254–71.

<sup>15</sup> IRBY-MASSIE & KEYSER 2002: 150–78.

<sup>16</sup> Daedalus, (Hellenic: «Skillfully Wrought») mythical Hellenic inventor, architect, and sculptor, who was said to have built, among other things, the paradigmatic Labyrinth for King Minos of Crete.

WHITE & et ALL. 1959: 558-60

<sup>17</sup> Labyrinth was the name given by the ancient Hellenics and Romans to a structure of bewildering maze of passages designed by Daedalus in the command of King *Minos* of Crete. WHITE & et ALL. 1959: 558-60

<sup>18</sup> Archytas of Tarentum, Hellenic scientist, philosopher, and major Pythagorean mathematician. HUFFMAN 2005: 255-82.

<sup>19</sup> DE SOLLA PRICE 1964: 9–23

the mechanical versions of «self-movers» were the reason for thinking that human beings' organisms, and the natural world in general, might work just like that <sup>20</sup> Thus, the emergence of automata had been greatly accepted and welcomed by the Hellenics, especially those who were resided in Athens, where slavery was widespread, and they rapidly understood that automata, self-moving robots, could substitute slaves <sup>21</sup>. Thus, the existence of slavery produced the raw materials for the development of a piece of technology; the «imaginary robots» automaton. As a result, turning to automata virtually became a must<sup>22</sup>.

### III. CONTRIBUTIONS OF MUSLIM MECHANICAL ENGINEERS IN AUTOMATA

The roots of every new civilization must be supported by the achievements of its ancestors. In the case of Islamic civilization, ancestors were basically the Hellenistic, Greco-Roman, and Byzantine civilizations, besides minor influences from China and India. By their conquest of Egypt and Syria in the first half of the 1<sup>st</sup> century AH/ 7<sup>th</sup> AD, the Arabs fell inheritor for the Hellenic civilization. This heritage was eventually to bear fruit in the transmission of scientific literature and in diffusion of traditions in the construction of machines, hydraulic works and masonry structures <sup>23</sup>.

Furthermore, from the mid of the 1<sup>st</sup> century AH/ mid of the 7<sup>th</sup> AD century, Muslim Arab armies built communication with the Chinese civilization during their conquest of Central Asia. In addition, China had long been a commercial and diplomatic representative in the area. Yet, the Indian influence on Islamic civilization had long occurred when Muslims established a vast subcontinental empire and arrived on the south Indian coasts as missionaries and merchants. In 93 AH/ 711 AD, the Umayyads annexed that part of India in the north, now known as *Sind*, which came into direct contact with the caliphate and was the main channel through which the ancient Indian sciences passed to Baghdad <sup>24</sup>.

The legacy of scientific and technological knowledge from the conquered regions had remarkable results in the new society. With the translation from Hellenic and other languages, there was a tremendous openness in the early centuries of Islam. In addition, the organized sponsorship of translation under the great '*Abbasside Caliphs*, which continued until the middle of 5<sup>th</sup> century AH/11<sup>th</sup> century AD, reflects the great attention the rulers paid to adopting all valuable knowledge of the pre-Islamic cultures

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<sup>20</sup> BERRYMAN 2003: 344–69

<sup>21</sup> WILSON 2008: 337–68.

<sup>22</sup> DEVECKA 2013: 52–69.

<sup>23</sup> HILL 1993: 1–14.

<sup>24</sup> AL-HASSAN & HILL 1986: 29–31.

as a matter of expediency. By about 442 AH/1050 AD all valuable scientific works of the Hellenistic period were available in Arabic. In addition, original Arabian works became an extension to Hellenic scientific systems and participated in improving them<sup>25</sup>.

Talking directly about «fine technology» in Islamic epoch; there are plentiful evidences of edited texts, besides some surviving instruments that testify on Muslims' contributions in producing mechanical devices<sup>26</sup>. Although the Muslim scientists had taken the Hellenic works as their starting point, they became considerably more advanced. According to references of Hellenic, Roman and Arabian historians, constructing ingenious devices had occurred in the Eastern Mediterranean from Hellenistic times and through the periods of the Roman and Byzantine empires into the world of Islam. Written sources that describe machines are very rare. In Arabic, likewise, there were some short treatises, only two are of great importance<sup>27</sup>.

The first is that of *Aḥmad* one of the three brothers known as the *Banū Mūsā*, sons of *Mūsā b. Shakir*; *Muḥammad*, *Aḥmad*, and *al-Ḥasan* <sup>28</sup>. *Mūsā b. Shakir* was so advanced in the field of engineering and astronomy; thus, he was one of the fortune-tellers during the reign of the 'Abbasside Caliph *al-Ma'mūn* (198-218AH/ 813-833AD). His three sons were superiors in mathematics, astronomy, and tricks «*Ḥiyal*».<sup>29</sup>

Although these three brothers undoubtedly took the works of *Philo* (200 BC), and that of *Hero* (mid of 100 BC) as their starting point, their work revealed a greater mastery over physical media that even exceeded their Hellenic predecessors. They were the pioneers of Islamic engineers to demonstrate a preoccupation with automatic controls<sup>30</sup>. They had about twenty scientific books, in mathematics, astronomy, and mechanics; the most famous of these was the «*Book of Ingenious Devices*» which had been dated to 3<sup>rd</sup> century AH/ 9<sup>th</sup> century AD and particularly attributed to *Aḥmad b. Mūsā*<sup>31</sup>. This book included a hundred of ingenious devices that helped in initiating technological refinements and offered new applications. It is critical here to mention that the mastery of *Aḥmad b. Mūsā b. Shakir* in the field of aerostatic and hydrostatic pressures, besides his employment of automatic controls and switching systems placed him in advance of his Hellenistic predecessors. Although his work in this field is limited in scope; it -his work- was not exceeded until modern times<sup>32</sup>.

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<sup>25</sup> HILL 1993: 2–14.

<sup>26</sup> DE SOLLA PRICE 1964: 9–23.

<sup>27</sup> HILL 1994: 25–43.

<sup>28</sup> AN-NADĪM 2014: 224 – 6.

<sup>29</sup> IBN AL-QIFṬĪ 1903: 315, AL- ANDALŪSĪ, 1912: 55, IBN KHALAKĀN 1977: 161-3.

<sup>30</sup> SARTON 1927:545–6; BROCKELMANN 1936: 382.

<sup>31</sup> SEZGIN 1974: 246–52; SEZGIN 1979: 129–30.

<sup>32</sup> RĀSHID 1996:1–31; SEZGIN 2001:107-298.



However, the most important Arabic treatise in mechanical engineering is the great book of ingenious devices of *Ibn al-Razzāz al- Ġazarī*, which was accomplished in 602 AH/ 1206 AD. In *Diyarbakir*. It encloses fifty machines, distributed into six categories; water-clocks and candle-clocks, wine dispensers, phlebotomy measuring devices and water dispensers, alternating fountains and musical automata, water-raising devices and miscellaneous<sup>33</sup>. Several of the mechanisms and their techniques that appear for the first time in *al- Ġazarī*'s work were later to enter the vocabulary of European mechanical engineering<sup>34</sup>. This work is almost important, since *al- Ġazarī* described, accurately, the methods of manufacturing and constructing his machines, accompanied by a practical study. This is a unique performance in earlier centuries, and thus, allowed later craftsmen to reconstruct his mechanisms<sup>35</sup>.

In the comparison between the work of *al- Ġazarī* and that of *Banū Mūsā*, it was stated that the work of *al- Ġazarī* reached a higher level of maturity than that of *Banū Mūsā*'s. In addition, according to Western scientists, the mechanical devices of *al- Ġazarī* were of great significance not only for achieving daily life functions, but for their importance in recognizing principles of natural physics as well<sup>36</sup>. The book of *al- Ġazarī* is the most detailed in its type, and the peak of Muslims' achievements in mechanical engineering<sup>37</sup>.

British engineer Donald Hill stated: «Until recent centuries; the book of *al- Ġazarī* is unique in its designs and detailed methods of manufacturing and forming machines; null documents from any other civilizations all over the world that corresponded to it».<sup>38</sup> Muslim engineers were almost in close contact with constructors; and only few of them had gathered between engineering and constructing machines; *al- Ġazarī* was a dynamic engineer and a professional constructor as well<sup>39</sup>. Conclusively, the book of *al- Ġazarī* had presented a full scene of Arabian mechanical technology<sup>40</sup>.

Getting to the impact of Muslim engineering on European technology; most of the Western historians deny Muslims' priority. They suppose that European culture is the direct descendant of the classical civilizations of Greece and Rome. However, according to Charles Singer, the 19<sup>th</sup> century British historian of sciences, the Greco-Roman heritage was built upon the great civilization of the Near Eastern achievements due to the scholars and artisans of Egypt and Syria. The pre-Islamic civilizations from Spain to Central Asia and northern India were inherited by Islam. Under the influence of Islam and the Arabic language; all scientific achievements of these regions have been

<sup>33</sup> SEZGIN 2001: 43-106.

<sup>34</sup> HILL 1994: 25-43.

<sup>35</sup> SARTON 1975: 510.

<sup>36</sup> SALIBA 2007:193-232.

<sup>37</sup> SARTON 1975: 510.

<sup>38</sup> HILL 1978: 222-37.

<sup>39</sup> SARTON 1975: 510.

<sup>40</sup> ALĠAZARĪ & et ALL -ḤASSAN (ed.) 1979: 49.



developed and improved<sup>41</sup>. Hence, the influence of Muslim mechanical engineering on the development of European machine technology can be verified through examining the antecedents of a single machine<sup>42</sup>. This indicates that the ideas of Muslim engineers in fine technology in general, and particularly the utilitarian inventions of *al- Ġazarī* were transmitted to the West<sup>43</sup>.

Here, we shall ask about the routes from which Muslim scientific ideas had reached to Europe. Actually, Muslim Christian Spain was the first entry point, and from there directly to northern Europe<sup>44</sup>. The second entry point for Muslim sciences to Europe was Sicily when it was part of the Muslim Empire, due to its proximity to mainland Italy. Additional way for transferring Muslim sciences and technologies to Europe was the crusaders, through their stay in the Near East, for they were admired with technological ideas and transferred them to Europe<sup>45</sup>. Furthermore, the translation movement which commenced in the 6<sup>th</sup> century AH/ 12<sup>th</sup> century AD greatly benefited by the collaboration of Muslim, Jewish and Christian scholars, as it facilitated the transfer of technological ideas, and intensely motivated the scientific evolution in Europe<sup>46</sup>. Though, there is no evidence that the Islamic treatises in fine technology ever translated into any European language before modern times<sup>47</sup>.

Some researchers had, incorrectly, assumed that Arabian mechanical technology based on aesthetic pleasure devices<sup>48</sup>. Nevertheless, contemporary historians of technology had stated that precise components of the ingenious devices of the *Banū Mūsā* and *al- Ġazarī* and their practical functions became the core stone for the development of European mechanical technology and the entire industrial evolution<sup>49</sup>. One of the most important components used by *Banū Mūsā* was conical valves since the 3<sup>rd</sup> century AH/ 9<sup>th</sup> century AD<sup>50</sup>, which first appeared in Europe in the notebooks of *Leonardo da Vinci*<sup>51</sup>. Remarkable mechanical water-clocks of *Banū Mūsā*; their identical samples had entered Europe later in the mid of the 6<sup>th</sup> and 7<sup>th</sup> centuries AH/ 12<sup>th</sup> and 13<sup>th</sup>

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<sup>41</sup> AL-HASSAN & HILL 1986: 31-34.

<sup>42</sup> HILL 1994: 25-43.

<sup>43</sup> CIGOLA & GALLOZZI 2000: 335-40.

<sup>44</sup> HILL 1994: 25-43.

<sup>45</sup> AL-HASSAN 2005: 1-30.

<sup>46</sup> ROMDHANE & ZEGHLOUL 2010:1-22.

<sup>47</sup> HILL 1993: 229-235.

<sup>48</sup> ALĠAZARĪ & AL-HASSAN (ed.) 1979: 50.

<sup>49</sup> DE SOLLA PRICE & HILL 1975: 81-83; SEZGIN 2001:43-106

<sup>50</sup> WIEDEMANN 1906: 6-8

<sup>51</sup> Leonardo da Vinci is an Italian painter, sculptor, architect, and engineer who lived through the 2<sup>nd</sup> half of the 15<sup>th</sup> century A.D and the 1<sup>st</sup> half of the 16<sup>th</sup> century A.D (1452-1519A.D). His painting known as *Mona Lisa* (c. 1503-19) is among the most widely popular of the Renaissance. His notebooks reveal that he had advanced mechanical ingenuity preceding his time.

FARAGO 1999: 70-76, 230-59.

centuries AD. Reaching to medieval Europe, all of these Muslim mechanical techniques were further simulated by the craft leagues<sup>52</sup>.

Furthermore, the achievements of *al- Ġazarī* are another superb ring among the Arabian mechanical engineering chain. He was the innovator of mechanic and hydraulic mechanisms that are still affecting contemporary mechanical engineering<sup>53</sup>. His book that is briefly entitled «*kitāb al-Hiyal*» was one of the sources that might have influenced *Leonardo da Vinci* in building some of his clocks<sup>54</sup>, this is besides a phlebotomy measuring instrument and the slot-rod pump that have been reconstructed by modern craftsmen using instructions of *al- Ġazarī*<sup>55</sup>.

In later epochs, several prototypes of *al- Ġazarī's* mechanisms had been built<sup>56</sup>. Of these the mechanical man - robot- from metal, wax, glass, and leather constructed by the German theologian Albertus Magnus<sup>57</sup>, in the 7<sup>th</sup> century AH/ 13<sup>th</sup> century AD. Thus, such sample gives a positive image of the advance of automation in Europe<sup>58</sup>. Another sample is a mechanical clock in Padua dated back to 765 AH/ 1364, attributed to *Giovanni de Dondi*<sup>59</sup>. This was a true mechanical clock with weight-drive, linkwork to show all the astronomical motions, a fully automated calendar showing Easter and other holydays, and a little dial for telling the time<sup>60</sup>. Further simulated samples are recent imitations of mechanical clocks of *al- Ġazarī*, which were on display during the *World of Islam Festival* in England in 1976 AD.<sup>61</sup> The first was a monumental water clock, which is now exhibited in Aston in the Netherlands. Other prototypes can be seen in Frankfurt, Germany and in Aleppo, Syria. A full-scale prototype can also be seen in a mall in Dubai<sup>62</sup>.

Conclusively, Muslim scientists had inherited all the sciences and technologies of the pre-Islamic civilizations in the Near East and all the lands, extending from Central Asia and northern India to Spain. All these sciences and technologies had been notably

<sup>52</sup> SEZGIN 2001:107-298, SEZGIN 2006:185-98.

<sup>53</sup> HILL 1978: 233.

<sup>54</sup> ROSHEIM 2016:117.

<sup>55</sup> HILL 1993: 112-40.

<sup>56</sup> ROMDHANE & ZEGHLOUL 2010: 1-22.

<sup>57</sup> Albertus Magnus is a German philosopher, theologian, scientist, and writer of the 13<sup>th</sup> century A.D. He was called doctor universalis for the great breadth of his knowledge. He studied liberal arts in the University of Padua.

SHAMPO & ROBERT 1985: 530.

<sup>58</sup> DE SOLLA PRICE 1964: 9-23.

<sup>59</sup> Giovanni de Dondi was an Italian physician, astronomer and mechanical engineer in Padua, now in Italy, who was born in 1330 A.D. He was particularly famed by his elaborate astronomical clock which he designed and spent sixteen years constructing, completing it in 1364 A.D

BEDINI & MADDISON 1966: 1-69.

<sup>60</sup> UNGERER 1931: 163-65.

<sup>61</sup> The World of Islam Festival is a unique cultural event that attempt to present one civilization to another. It included several exhibitions from more than 30 countries. One major exhibition, the first of its kind ever held, was that on "Science and Technology in Islam".

SABINI & KEEN 1976: 2-4.

<sup>62</sup> ROMDHANE & ZEGHLOUL 2010: 1-22.

improved due to the intensive consideration of the Muslim rulers<sup>63</sup>. Concurrently to the maturity of technological sciences in Islamic civilization, Europeans were still beginners<sup>64</sup>.

Unfortunately, despite multiple indications to the favor of Arab-Islamic civilization in providing Europe with the basics of its scientific and technological advance, the majority of contemporary writings of the Westerners hardly acknowledged<sup>65</sup>.

#### IV. MUSLIMS' AUTOMATA MECHANISMS ACCORDING TO MINIATURES OF «KITĀB AL-HIYAL»

**The 1<sup>st</sup> miniature: A musical robotic band on a boat during a drinking party (4<sup>th</sup> chapter of the 2<sup>nd</sup> category), [FIGURES 4, 5, 6]**

This device looked like a wooden boat with a domed platform on the stem. This boat was designed to float on a lake's surface to entertain guests during royal drinking parties. A seated figure of a king, made of papier mâché, is on the platform, his chamberlain «*ḥājib*» standing to his right-hand side, while his weapon-bearer standing to the left side. Before the king's figure is a slave holding a jug and a goblet. Figures of boon companions of papier mâché, as well, are shown seated to the left and right sides.

On the opposite side of the king is a platform, where four automated figures of papier mâché resembling musicians, two drummers, a harpist and a flautist, are seated. Behind the platform is a sailor holding the boat's rudder. Another sailor is standing on the boat's upper side holding an oar<sup>66</sup>.

The core mechanism of this device is a rotating cylindrical beam with protruding pegs; these just bump into little levers operating the beating. The point of the model is to demonstrate that different rhythms and drum patterns could be originated by the drummer if the pegs are moved around<sup>67</sup>. The device is composed to perform a specific action; all musicians play their instruments, and then all of them get silent. This was to be repeated for about fifteen times at intervals of about half an hour.

The movement of the hands of the slave-girls and the instrument responsible for the flute's sound is a copper reservoir forming the platform, over which the slave girls are seated, and behind them is an inlet hole for the water. A tipping bucket is made, with a trough beneath it, where both are placed under the reservoir towards the boat's central part over a stable base. Beneath the reservoir's outlet is an axle in a crosswise direction.

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<sup>63</sup> AL-HASSAN 2005: 1–30.

<sup>64</sup> SINGER & AL. 1979: 756.

<sup>65</sup> CIGOLA & GALLOZZI 2000: 335–40.

<sup>66</sup> AL-ĠAZARĪ 1485: FOLIOS 16-19.

<sup>67</sup> ÖREN 2001: 63–70.

A scoop-wheel with a trough, beneath it, is fitted to the right end of this axle. Water discharges from a pipe in the tipping bucket's trough over the scoops of the wheel. The reservoir's bottom is perforated to let water dripping into the tipping bucket, until it gets full, and then, all the water is discharged into the underneath trough. The next step, water was drained out from the trough, through a pipe, and falls on to the wheel's scoops. Water has been collected on the trough beneath the scoop wheel and flows from it, through a narrow pipe, into a vessel. This vessel is made for the whistle, having a siphon and a pipe terminated with a whistle ball placed in the flute- playing slave-girl. Water discharged from this vessel was collected in the boat's floor<sup>68</sup>.

The platform, where the figures of the four slave-girls (flautist, harpist, two tambourine players) are seated, had been perforated. Parallel holes were vertically applied in the reservoir's floor. A piece of pipe was inserted in each hole, with their ends soldered to the reservoir's roof and floor as well. The pipe with the flute's ball is inserted into the hole beneath the flautist, the ball entering the hollow in the flautist, who is placed in position and soldered to the platform, the sound issues from her sleeve. The right-hand and forearm of the tambourine-player moves about an axle whose ends are fixed in her sleeve. In its end is a hole where a copper rod «*shazīya*» with a ring-shaped end was inserted and moves in the hole at the end of the forearm. The rod's other end goes through the hole under the tambourine player below the platform, so close to the scoop wheel's axle. Then the rod's end is bent right at the axle's direction. A short peg is fitted to the axle, thus when the scoop-wheel rotates, the peg's end comes down to the bent-up end of the rod for the hand and presses it down causing the hands moving up and down. The other tambourine player is made similarly.

The harpist is made, like others, of jointed copper, in which the harp is placed vertically on the player's left thigh. The player's both hands are constructed to move with the fingers over the strings without touching them. A hole with a hanging down rod is applied in the extension of each forearm, similar to the tambourine player's rod. The two rods go down through a pipe underneath the harpist. For the movement of the right hand; three pegs, similar to the one fitted for the tambourine player's hand, are fitted to the axle. A board is installed behind all the rods descending from the slave-girls to prevent them from falling backwards.

Thus, the logic sequence of this device working was beginning when the water reservoir, slave-girls' platform as well, was filled with water; this drips from the reservoir's underside into the tipping bucket. The bucket gets filled with water in about half an hour, thus discharges water into the trough. As a result, water flows on to the wheel's scoops and thus the wheel turns. As a result, the pegs move the rods hanging

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<sup>68</sup> AL-ĠAZARĪ 1485: FOLIOS 16 -19.

down from the slave-girls' hands. The water is sucked down into the pipe which connects the wheel's trough to the whistle's vessel, displacing the air from the vessel to within the whistle's ball. When the vessel is full, and the water has risen above the siphon, it flows out into the vessel's bottom, whence it returned to the reservoir in the next day [FIGURE 6]<sup>69</sup>. Such device is the first known automated musical band. Accordingly, *al- Ġazarī's* musical boat's system is an inspiration for a musical robot live-coding system bearing his name<sup>70</sup>.

**The 2<sup>nd</sup> Miniature: A Pitcher for Wine (10<sup>th</sup> Chapter from the 2<sup>nd</sup> Category), [FIGURE 7].**

The ingenious device discussed here is an automated drinking machine that was exploited by the rulers and the elites during parties. It is composed of a wooden cupboard with two brass leaves. Within the cupboard is a hollow papier-mâché figure of a slave girl grasping a glass and a towel while standing over a board with four rollers of cast- bronze fitted on axles cross-wise in slots at the board's corners.

At the same width of the cupboard, a copper reservoir, with an upper hole for pouring wine, is attached. Below the reservoir is a trough with a tipping bucket. The reservoir's floor was pierced, and a short pipe had been attached. Hence, the wine drips into the bucket, which in turn was pierced in its bottom and a short pipe is attached vertically on the board, so the wine is poured within the glass grasped by the slave-girl while inside the cupboard.

The mechanism of this device is based on the moving of the slave-girl's hands; the right hand grasps a wine glass, in her elbow is an axle that is responsible for the elbow's move up and down. A rod is penetrating the slave-girl's back, causing it to be pushed back within the cupboard, because its -slave-girls'- weight with an empty glass is lighter than the bent-down angle of rod. However, when a determined quantity of wine (or water) is poured into the glass, the slave-girl's weight became heavier than the rod, and thus, the angle lifts off the bar. The slave- girl runs rapidly towards the cupboard's door. As a result, the wooden leaves open; the slave-girl's figure emerges at intervals, about eighth of an hour, while bearing a cup of wine in its right hand, and a small towel (*mandīl*) in her left hand. The king takes the cup and drinks the wine included, and then he puts the cup back to the slave's hand. In addition, he can use the small towel to clean his mouth, if he wishes, and then closes the wooden leaves. The same steps are repeated at equal intervals<sup>71</sup>.

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<sup>69</sup> AL-ĠAZARĪ 1206: FOLIOS 69-71, AL-ĠAZARĪ 1485: FOLIOS 16 -19.

<sup>70</sup> DIMAROGONAS 2001: 14.

<sup>71</sup> AL-ĠAZARĪ 1273: FOLIO [N.K], AL-ĠAZARĪ 1485: FOLIOS 35-38.

### The 3<sup>rd</sup> Miniature: A Peacock-Shaped Hand Washing Device (9<sup>th</sup> Chapter from the 3<sup>rd</sup> Category), [FIGURES 8, 9]

The main occupation of this ingenious device is to work as a robotic machine for washing hands or perform ritual ablutions. Its performance is based on the peacock pouring a little amount of water from its beak on the master's hands.

This device is composed of a brass wide based basin resting on a pedestal. The basin's base is divided into two equal parts; one of which equipped with four columns; two are attached on the basin's center; however, the other ones are supporting the basin's square corners. The right-hand column had been perforated and a tube was inserted, which -in turn- penetrates the basin's floor to discharge water away. The columns' upper edges are topped by a rectangular castle, its frontal side had been penetrated by two adjoining doors, each with two leaves moving on hinges. Behind the right-hand door, is a hollowed figure of a slave made of jointed copper. The slave figure is shown standing on an axle above the castle's floor, and holding a jar containing saltwort (*ūshnān*)<sup>72</sup>. An arrow is fixed rigidly to the axle, reaching to the topmost of the right-hand column, which had an opening to discharging water. The slave is slanted towards his rear, while bearing the jar behind the door leaves being locked. The castle's floor is perforated and connected with the columns' hollowed part reaching to its foot. Thus, if the rod rises from the column; this will upraise the bar's end, which in turn slopes the slave forwards. As a result, the slave pushes the door leaves with the jar he is holding, thus, the door leaves open and the slave emerges, hence, the master could take what he needs.

The castle's left-hand door, similar to the right one, had a slave standing on an axle's attached bar, the end of which extends to the central point of the other, non-penetrated, column on the edge. Thus, a hole had been made on the castle's floor, which goes through into the column's hollowed core. If the end of a rod rises from the column's top; it will raise the bar's end, and thus, tilting the slave forwards. As a result, the slave's hands which hold the small towel -for the master to dry his hands- open the door leaves, and the slave emerges out of the door [FIGURE 8]<sup>73</sup>.

The device's main basin is resting on a pedestal soldered beneath the four columns. This pedestal had been perforated with two holes; through the basin's floor into the two columns' hollowed cores. On the pedestal's floor is an average sized float with a vertical jar shaped chamber, vertically beneath the column with the aperture in its foot. Then a light rod is fixed vertically to the float's top part. When water is poured into the basin's

<sup>72</sup> *Ūshnān* is a type of trees that is planted in sandy soils; used in washing both clothes and hands, useful for curing some dermal diseases such as itch. In addition, «*tā'shan*» meaning washed hands by.

AL-FAIRŪZ ABADĪ 2008: 57-8.

<sup>73</sup> AL-ĠAZARĪ 1273: FOLIO [N.K].



floor; it flows out from the basin's floor hole into the float's chamber, causing it to rise, until the rod lifts the outermost part of the axle's bar, which tilts the slave, thus, opens the door leaves.

On the castle's roof a hollow, big-sized peacock of jointed copper is standing, its neck curved down from its center to its lower end. Both beak and head are somewhat lower than its belly. The peacock's neck is penetrated, and a narrow siphon inserted. The siphon's one tip is in the peacock's back, while the other tip is on the floor of the peacock's belly. An opening is made between the cavity in the tail and that cavity in the peacock. Thus, if water was poured into the uppermost of the tail, it will flow inside the peacock's body. The tail is divided, vertically, by a thin plate into two parts (chambers), so when water was poured into the tail's uppermost, it will be filled since the water has no outlet. In the center of the dividing plate is a hole with a ground valve and a watertight is made. The plug goes down into the seat from above. On the plug is a rising rod, the end of which is bent towards the back of the tail, which had a ring moves upwards firmly in a narrow slit. The tail's uppermost part has a wide opening to pour water. When water filled the peacock's body and half of its tail; water rises through the ground valve. Until now, the water has not reached the bent part of the siphon in the peacock's neck, but slightly below it. Though, when the ring is pulled up, the valve is opened, thus, water in the tail's lower chamber mixed with that in the upper one. Thus, water rises above the bend in the siphon.

When the basin is needed, the real servant places it in front of his master, he pulls the ring quickly, and thus water flows from the peacock's beak on the master's hands. The water flows and runs out from the opening in the perforated column on the basin's edge and fills the float's chamber. As a result, the float itself is raised, the rod is raised as well, the bar on which the slave stands to be raised, as a result, the slave bearing the jar with saltwort (*ūshnān*) comes out of the doors, the master takes what he needs, and performs his ritual ablution. When the rest of water runs from the basin's floor down to the pedestal, and the pedestal in turn became almost full; the second float has risen and in turn rises the axle's bar where the other slave, holding the towel, standing. Thus, the slave slopes, opens the leaves and emerges from the door [FIGURE 9]<sup>74</sup>.

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<sup>74</sup> AL-ĠAZARĪ 1206: FOLIOS 98-100, AL- ĠAZARĪ 1485: FOLIOS 60-65.

**The 4<sup>th</sup> Miniature: A Hand Washing Automaton with Flush Mechanism (10<sup>th</sup> Chapter from the 3<sup>rd</sup> Category), [FIGURES10, 11].**

This ingenious device was to work as a robotic machine for washing hands or to perform ritual ablutions. This device is composed of a square shaped stage «*kursī*» of brass with a kneeling slave holding a brass pitcher in his right hand, while catching a towel and a comb in his left hand. On the stage's «*kursī*» corners, four columns are supporting a castle thoroughly soldered and served as a tank. This castle is crowned by a dome and a standing bird on. Adjacent to the stage «*kursī*», directly under the pitcher, is a half basin, the floor of which is occupied by a handsome crouching duck, with neck raised up, then bent down to the middle, thus its beak touches the basin's floor. A narrow siphon is inserted in the duck's neck, one tip of the siphon is in the bird's beak, while the other tip goes along its rear through the basin's side into the stage's «*kursī*» cavity, and then brought down lower than the basin's floor. The device had two valves one on top of the castle, and the other is on the stage's «*kursī*» foot.

The mechanism of this device is as follows; when the master needs to wash his hands or perform his ritual ablution, the real servant brings this device in front of the master. The servant opens the castle's upper valve, the water descends from the pipe and flows down to the within the pitcher, the air into the pitcher is driven out through the other pipe. Thus, the ball whistles giving impression that the sound comes from the bird's beak. Water flows from the pitcher's spout until the master performs his ritual ablution. Thus, the water accumulated on the basin's floor, and thus being drunk by the crouching duck. Furthermore, the slave stretches his left hand with towel and comb towards the master [FIGURE 10].

Concerning the mechanism of the whistle and the calculated time of pouring water; the pitcher is divided vertically into two chambers and sealed with a plate on its top. Below the pitcher's handle; there are two holes with jointed pipes. One pipe goes from the handle through the slave's palm into his upper arm, where a whistle's ball is fixed in its end, and topped with three columns, the castle, the dome and the bird topping it. The other pipe, which was responsible for calculating time, was fitted through the slave's palm and bent down at his elbow, and then bent down his skirt along the stage «*kursī*». Again, the pipe rises up through the castle's right-hand column. The valve's upper tip and its plug go up to the castle's top. At the spout's place is a hole, in which the siphon's end is inserted to touch the plate dividing the pitcher.

On the castle's floor a pipe is fixed, which goes down through the right-hand column behind the slave. This pipe is turned under the stage's «*kursī*» deck and rises within the slave's hollowed center. Its end is connected to the pipe's terminal, which comes up from the pitcher's handle and goes through the slave's palm and sleeve. Then a float is made, with a staple fixed in its upper circle, linked to a rope. This float is

placed on the stage's «kursī» floor, with a hole in the deck below the staple in the extension of the slave's left-arm. When the float rests on the stage's floor; its weight pulls the extension of the slave's elbow and lifts his hand with the towel and the comb. However, when water runs into the stage «kursī», the float rises and thus, the slave's hand sinks [FIGURE 11]<sup>75</sup>. When the master finishes using them, he put them back on the slave's left-hand. Finally, the real servant takes the basin away, opens the side tap to extract water that had been drunk by the duck<sup>76</sup>.

## V. HISTORICAL AND ARTISTIC ANALYSIS FOR THE PUBLICATION OF «KITĀB AL-ĤIYAL»

### Author's Biography

He is *al-Sheikh Rais al- 'ūmāl Badii' al-Zamān Abu al- 'Izz ibn Isma' il ibn ar-Razzāz al- Ġazarī*<sup>77</sup>, He lived most of his life away from his homeland in *Diyarbakir* in upper *Mesopotamia*,<sup>78</sup> since the 2<sup>nd</sup> half of the 6<sup>th</sup> century AH/ 2<sup>nd</sup> half of the 12<sup>th</sup> century AD. He was called *al- Ġazarī* due to his residence in an island 'ğazīrah' between *Tigris* and *Euphrates* rivers. He was in the service of *Artuqid* rulers in *Diyarbakir* since *Nūr el-Dīn Mūḥammad ibn Arsīlān* (570 -581 AH/ 1174- 1185 AD), then *Qūtb el-Dīn Sakman ibn Mūḥammad* who took control over *Diyarbakir* from 581- 597AH/ 1185 - 1200 AD, and later under the control of *el-Malik el-Şāliḥ Nāşir al-Dīn Abu'l Faṭḥ Maḥmūd b. Muḥammad b. Qara Arslān b. Daud b. Sukmān b. Artuq* who ruled from 597 to 619 AH/ 1200 to 1222/3 AD<sup>79</sup> *Al- Ġazarī* worked on his book «*Al- Jāmi' byna al- 'ilm wā al- 'amal al-naḥfiā' fī Şinā' at al-ḥiyal*» by request of *Nasir el-Dīn Maḥmūd*. According to Oxford manuscript, he accomplished it after about seven years; in 4<sup>th</sup> of *Jūmādah al-Ākhirah* 602 AH/ 16<sup>th</sup> of January 1206 AD. Nevertheless, it was recorded that his experience in mechanical engineering started from 571 AH/1175 AD, and basically in inventing and building mechanisms. Hence, he is the most famous mechanical engineer from the pre-medieval era.

### Scientific Standing of «*kitāb al-Ḥiyal*»

This book known as «*Al- Jāmi' byna al- 'ilm wā al- 'amal al-naḥfiā' fī Şinā' at al-ḥiyal*» presents a wide variety of ingenious devices and mechanisms employed for different purposes. Though, these devices' main objective, sometimes, limited to amusement; they were skillfully modeled with delicate mechanisms, and highly precise control systems<sup>80</sup>. The Arabic word «*al- ḥiyal*» when used in mechanical field almost refer to

<sup>75</sup> AL- ĠAZARĪ 1485: FOLIOS 65-68.

<sup>76</sup> AL-ĠAZARĪ 1206: FOLIOS 100-102.

<sup>77</sup> ROMDHANE & ZEGHLOUL 2010: 1-22.

<sup>78</sup> *Diyarbakir* was located in upper *Mesopotamia*, on the western branch of *Tigris* river, now in southern Turkey. Anciently, it was called 'Āmid'; the walls of which were marvelous calligraphic museum.  
ALĠAZARĪ & AL-ḤASSAN (ED.)1979: 37.

<sup>79</sup> *Artuqid* dynasty is attributed to *Artuq ibn Aksab al-Turkumani*, one of the slaves of *Suljuq* sultan *Malikshah*, who took over control on Jerusalem after conquered by *Suljuq* commander *Tettch*.  
ALĠAZARĪ & AL-ḤASSAN (ED.)1979: 36.

<sup>80</sup> ROMDHANE & ZEGHLOUL 2010: 1-22.

special sort of mechanisms; basically, those meant to bestow pleasure and amusement for the rulers and the elites. Although some of these devices were released as being insignificant, many of the ideas and components embodied in had greatly contributed in improving modern technologies<sup>81</sup>. Definitely, the work of *al- Ġazarī* is the head of Muslims' achievements and deserves to be designated as the prior valid study in systematic machinery design<sup>82</sup>. This manuscript included 50 different devices, which can be concluded into six types, these are; different clocks, Automata vessels, water dispensers, fountains and musical automata, water raising machines, besides other miscellaneous machines<sup>83</sup>. Mainly fountains and musical automata devices were designed by using several hydraulic switching techniques. By virtue of these revolutionary devices, *al-Ġazarī* owed the title of 'the father of robotics'<sup>84</sup>. This book had been translated several times since the first quarter of the 14<sup>th</sup> century AH/20<sup>th</sup> AD, however, the most known translation is by Donald Hill in 1974, entitled «The Book of Knowledge of Ingenious Mechanical Devices»<sup>85</sup>.

### Historical Analyses for the Publication of «*kitāb al-Hiyāl*»

Numerous copies of «*kitāb al-Hiyāl*» are conserved in several museums worldwide, until 1979 AD there were about 15 copies. They are varied in date; from 6<sup>th</sup> century AH/ 12<sup>th</sup> century AD to later ones of the 12<sup>th</sup> century AH/ 18<sup>th</sup> century AD. Another dissimilarity between these copies is their status, whether, complete or incomplete, in good, moderate or bad status, etc. Though, there are about six copies of extreme significance, these are to be described in detail as follows;

#### 1. Top Kapi in Istanbul (*Aḥmad III* N<sup>o</sup>. 3472)

It is the oldest known copy, which had been transcribed probably in 602 AH/ 1206 AD. The manuscript's folios are numbered in later time technique from 1 to 356. It includes folios with both scripts and printings of styles more recent than the original ones. Nonetheless, such recent paintings are of minor artistic mastery than the original ones. New folios are about 11 ones making 22 sheets. This manuscript had been ended with a text referring that it was copied by *Mūḥammad ibn Ūthman al-Ḥaškafī* from an earlier copy for the original manuscript. However, figures, shapes and symbols of the copy earlier than that of *al-Ḥaškafī* had been prepared by *al-Ġazarī* -may God bless his soul- himself. Actually, it could be stated that this copy is the best, although not void of

<sup>81</sup> AL-ḤASSAN & HILL 1986: 59–60.

<sup>82</sup> DIMAROGONAS 2001: 14.

<sup>83</sup> ROMDHANE & ZEGHLOUL 2010: 1–22.

<sup>84</sup> NOCKS 2007:152–55.

<sup>85</sup> ROMDHANE & ZEGHLOUL 2010: 1–22.

faults; it is almost complete in good calligraphy and fine paintings <sup>86</sup>. Thanks to the institute of Arabian scientific heritage- *Ḥalb* University in Syria for microfilming this precious manuscript<sup>87</sup>, and indexed it as N<sup>o</sup>. 1739<sup>88</sup>.

## 2. A Copy Dated back to 715 AH/ 1315 AD

This was once thought to be an incomplete copy; however, it was realized later that two thirds of the original copy had been sold in an auction in London in 1978 AD. This copy was documented to be transcribed in *Ramadan* 715 AH/ December 1315 AD by the scribe *Farkh ibn ‘ Abd el-Latīf*. Due to its date, this may be the 2<sup>nd</sup> or the 3<sup>rd</sup> in order from oldest to most recent copies. Despite being incomplete and had comprised some incorrect spelled words; it is designated as one of the best copies; with good script and fine paintings<sup>89</sup>.

## 3. *Hagia Sophia «Ayasofya»* Manuscript N<sup>o</sup>. 3606

This is one of the oldest copies of « *kitāb al-ḥiyal* ». It had been transcribed in 755 AH/ 1354 AD. Historians of Islamic arts have considered it the best. Unfortunately, several paintings had been lost, and being sold separately all-over diverse museums of arts. Furthermore, the transcript in no less than 17 parts is lost either. Nonetheless, it is still believed to be one of the best copies.

## 4. *Top Kapi Sarai Istanbul*, Manuscript Bookcase N<sup>o</sup>. 414

This copy had raised a great conflict in dating it. Several suggestions refer to 602 AH/1206 AD, but still doubtful, however, others dated it back to 672 AH/1273 AD. This copy was described to be composed of 175 folios. It is recently known to researchers, who classified it among the best outstanding copies, though about 10 to 12 sheets had been lost, while others had been shredded<sup>90</sup>.

## 5. Bodleian Oxford, Graves manuscript N<sup>o</sup>. 27

This is almost a complete copy in good script and fine paintings, dated back to 891 AH/ 1486 AD. It is of recent date than previously mentioned copies, though, it is distinguished by the alphabetical letters used on numbering paintings, unlike previous copies where paintings had unclear symbols. This copy had been basically used by two German physicists and historians of sciences, Eilhard Wiedemann and Fredrich Hauser,

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<sup>86</sup> ALĠAZARĪ & AL-ḤASSAN (ED.)1979: 39- 45.

<sup>87</sup> AL-ĠAZARĪ 1206:1–365.

<sup>88</sup> ‘ŪMAR 1986:72.

<sup>89</sup> ALĠAZARĪ & AL-ḤASSAN (ED.)1979: 40, 41.

<sup>90</sup> AL-ĠAZARĪ 1273: 1–175.

whom had translated some chapters to Dutch in the 1<sup>st</sup> quarter of the 20<sup>th</sup> century AD. In addition, Donald Hill; the English engineer and historian of sciences and Technology had, as well, depended on this copy to produce the first complete and most famous translation to this valued manuscript of *al-Ğazarī* in the last quarter of the 20<sup>th</sup> century AD.

#### 6. Paris National library, Arabian manuscript N<sup>o</sup>. 2477

This copy is dated back to 890 AH/ 1485 AD. It includes one chapter of *al-Ğazarī*'s book dealing with drinking session, besides, a part of the 6<sup>th</sup> type, though, unfortunately with no paintings. This copy is of good script; however, its paintings are of moderate quality and had no symbols<sup>91</sup>.

#### Artistic Analyses for the Publication of «*kitāb al-Hiyal*»

Painting is one of the main branches of Islamic Art. It has gained great fame and popularity due to its significance in depicting the social, economic, and cultural environment through consequent Islamic epochs, and in the vast regions of the Muslim Caliphate. Such paintings had been applied on walls, besides multiple types of manuscripts<sup>92</sup>. Paintings included in these manuscripts are known as «miniatures». These could be categorized into two types; one of them referring to the finely elaborated miniatures, employed to adorning literary books. The other type was the miniatures employed to explain text in scientific books, these almost disregard the artistic features, thus came of lesser quality. The manuscript of «*kitāb al-ḥiyal*» for *al-Ğazarī* is one of the valuable scientific books with miniatures<sup>93</sup>. More specifically, this manuscript is of a type known as «automata miniatures», representing mechanical devices. Some artistic historians had attributed this type to the end of the 6<sup>th</sup> century AH/ 12<sup>th</sup> century AD. Though, others had assigned them to the mid of the 8<sup>th</sup> century AH/ 14<sup>th</sup> century AD accurately (752 - 755 AH/ 1351-1355 AD), and supposed them to be of Egyptian provenance<sup>94</sup>. Nevertheless, a 20<sup>th</sup> century scholar called Coomaraswamy had managed to prove that the manuscript of «*kitāb al-ḥiyal*» for *al-Ğazarī* from the beginning of the 7<sup>th</sup> century AH/ 13<sup>th</sup> century AD is the initial sample for «automata miniatures»<sup>95</sup>.

The original copy which had been granted to the *Artuqid* sultan in *Diyarbakir* was lost. However, there are two indications that it was embellished with miniatures; the first is that later known copies were accompanied by miniatures, among which was a

<sup>91</sup> ALĞAZARİ & AL-ḤASSAN (ED.)1979: 41-45.

<sup>92</sup> BAHNASİ 1986: 23.

<sup>93</sup> AL-BĀSHĀ1959: 92-4.

<sup>94</sup> RIEFSTAHL 1929: 206–15

<sup>95</sup> COOMARASWAMY 1924:1–21.



human figure accompanied by the name of *Sultan Nūr el-Dīn Mūḥammad* (1174- 1185). The second indication is the identity of style of miniatures in all copies although they had been transcribed in different regions and through several epochs. This is probably due to the accuracy and honesty in transcribing <sup>96</sup>.

Through the long history of the Islamic civilization; painting, like all other types of Islamic arts, had passed by several stages. These can be divided into four technical schools; Arabian, Persian, Indian Mongolian, and Turkish, each with special features and diverse centers<sup>97</sup>. The manuscript of «*kitāb al-ḥiyal*» for *al-Ġazarī* is attributed to the Abbasid technical school in Iraq which is one of the main centers of the Arabian school of painting<sup>98</sup>.

Paintings of the Arabian technical school are distinguished by several features; generally, the tendency towards unreal representations; neglecting the illustration of landscapes, disregarding the embodiment of varied depth, and giving great concern to human figures, which are presented modified. Additionally, Arabian paintings were simple, frameless, with straight line shaped ground and plain, almost gilded, backgrounds. Besides, multiple lustrous colors are employed in the numerous elements of the diverse paintings<sup>99</sup>.

Human figures were characterized by Arabian facial features influenced by the Byzantine and Syrian Christian features. Once the scene had a master figure; the Arabian artist used to drag attention to this figure by depicting it in a larger scale than others, and by lavishly adorning his costumes and all his equipment. In addition, Arabian paintings had been characterized by drawing halos around human heads, without any symbolism, but to strike the sight. Such haloes were sometimes applied around heads of birds and around variant vegetal ornaments as well<sup>100</sup>.

Costumes were usually loose with broad sleeves adorned on upper arms with bands of calligraphy or diverse ornaments. Likewise, Costumes usually had folds applied in simple lines, in geometrical drawings, or diverse shapes of vegetal ornaments, animals, spheres, crescents, or foliated Arabian decoration known as «*arabesque*».<sup>101</sup> Other forms

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<sup>96</sup> ḤASSAN 1955: 16-19.

<sup>97</sup> FARGHALĪ 1991:12.

<sup>98</sup> The Arabian school of painting is the earliest Islamic technical school of manuscripts with miniatures. It had been spread all over the Islamic world. Iraq was the pioneer center for manuscripts with miniatures according to artistic features of the Arabian technical school, these were produced in *Baghdad*, *Diyarbakir*, *al-Mosul*. Other centers were Egypt and Syria during the Mamluk epoch. A later center was Iran during the *Seljukian* and *Mongol* epochs. Nevertheless, Baghdad was the best and the most important. It is worth mentioning that the earliest manuscripts bearing features of this Arabian technical school had been dated back to the end of the 6<sup>th</sup> century A.H/ 12<sup>th</sup> century A.D.

AL-BĀSHĀ 1959:125.

<sup>99</sup> AL-BĀSHĀ 1959: 128.

<sup>100</sup> ḤASSAN 1955: 16.

<sup>101</sup> Arabesque is an Islamic form of conventionalized vegetal ornaments composed of spiral or stylized waves and abstract elements.

of costumes' folds were more complicated; in shape of lines flowing from a central point, wavy lines, or gathering worms<sup>102</sup>.

Despite being a technical treatise, miniatures of the book of *al Ġazarī* are of great artistic value. All illustrations had been superbly colored, and had great artistic virtue<sup>103</sup>. Though, due to the multiplicity of copies and the distinction in quality between them; the researcher's attached plates are mainly relied on four copies; *Top Kapi* in Istanbul (*Aḥmad III* N°. 3472) dated back to 602 AH/ 1206 AD [FIGURES 5, 9, 11], the Copy dated back to 715 AH/ 1315 AD [FIGURES 4, 8, 10], *Hagia Sophia «Ayasofya»* manuscript N°. 3606 dated back to 755 AH/ 1354 AD [FIGURE 7] and Paris National library (Arabian manuscript, N°. 2477) dated back to 890 AH/ 1485AD [FIGURE 6].

Confining our analysis to bring forward the characteristics of Arabian technical school of painting that are clearly applied on the miniatures of «*kitāb al-Ḥiyal*», these are:

- Human figures in miniatures of «*kitāb al-Ḥiyal*» enclose Byzantine and Christian Syrian impacts which were widely known in *Diyarbakir* due to its historical and geographical circumstances [FIGURERS 4, 7, 8, 10].
- Costumes are loose, with wide sleeves adorned on the upper arm with plain bands [FIGURE 4], others with diverse ornamented bands [FIGURE 7].
- Human heads are surrounded with halloes [FIGURES 4, 7, 8, 10].
- Paintings' background is plain [FIGURES 4, 7, 8, 10].
- Abstract vegetal ornaments «*Arabesque*» are applied on several locations; on the domed platform [FIGURE 4], on costumes [FIGURE 7], and the domed castle of the stage [FIGURE 10].
- The master human figures in [FIGURES 7, 10] are depicted in a large scale than other elements with lavishly adorned costumes.
- Costumes' folds are applied in a more real form; in shape of lines flowing from a central point [FIGURE 10].
- Water is depicted in a wavy form or gathering worms [FIGURES 4, 5, 8, 9, 10, 11].
- Miniatures are applied in lustrous multiple colors [FIGURES 4, 7, 8, 10].

Although several copies of «*kitāb al-Ḥiyal*» had not been transcribed in *Diyarbakir*; their miniatures are almost alike. In addition, all the copies are in strong relation with *Diyarbakir* features, which had been influenced by Byzantine and Christian Syrian features once spread in the North of *al- Ġazīrah* and Northern of Syria<sup>104</sup>. In addition, the «automata miniatures» had a unique significance in their broad decorative conception, which had qualified them to be among the most valuable remaining miniatures.

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KHAZÂIE 2005: 27-50.

<sup>102</sup> AL-BĀSHĀ 1959: 127-9.

<sup>103</sup> ROMDHANE & ZEGHLOUL 2010: 1-22.

<sup>104</sup> COOMARASWAMY 1924: 1-21.

Generally, these miniatures' perfection reflects how supremacy was the Islamic civilization at the end of the 6<sup>th</sup> century AH/ 12<sup>th</sup> century AD<sup>105</sup>.

## VI. CONCISE SCIENTIFIC ANALYSIS FOR THE CHOSEN AUTOMATA MECHANISMS

As mentioned before, this research paper's chief aim is to illuminate how the Muslims were so advanced in mechanical engineering since the medieval ages; known as the golden age for the Islamic Civilization, and on the contrary, the Dark ones in Europe. No doubt, Muslim engineers had built most of their knowledge upon their predecessors, though; they were seniors in practical applications.

This paper focuses on four samples of automata «self- moving» mechanisms, to demonstrate a link between these primary samples and their modern counterparts, taking into consideration, the difference according to the long distance of time. Furthermore, this point is intended to concisely reveal how these primary samples of automata mechanisms had produced innovative techniques, still employed – in a more advanced way- in several modern industries. Besides, these automata mechanisms had presented numerous mechanical components of diverse duties that are still in use in modern industries.

Nevertheless, due to the complexity of the field of mechanical engineering to the non-specialists; the researcher had contented with a concise scientific survey on the mechanical techniques employed in automata mechanisms of *al- Ġazarī*, as follows;

- In the device of the musical robotic band [FIGURES 4, 5, 6] *al- Ġazarī* had used the hydraulic switching power, which is a system based on power transmission forces of liquids either static or dynamic. This became the base for modern hydraulic systems widely employed in modern industrial applications to transmit power from the prime mover to operate machine parts or vehicles. This system is widely employed in ship lock gates, movable bridges, agricultural equipment, etc <sup>106</sup>.
- In his automated drinking device (a pitcher for wine), *al- Ġazarī* used humanoid automata. This device's main mechanism is [FIGURE 7] a slave-girl acting as a waitress, applied in a hollow human-shaped mobile robot, with a complex mechanical design for moving the arms with axle and bars attached to control their moving up and down. Recently, composing human-shaped robots have been developed and widely spread in all fields of modern industries. Of these, science fiction and mass media which finely exploited humanoid robots in

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<sup>105</sup> RIEFSTAHL 1929: 206–15.

<sup>106</sup> THEISSEN & MURRENHOFF 2014: 31-77.

advertisements. In addition, humanoid robots are used for research into the mechanics of walking and into human-machine interaction<sup>107</sup>.

- The peacock basin for washing hands [FIGURES 8, 9] had been working by the hydropower mechanism. This converts the power of falling water into mechanical energy. What is interesting here is that hydropower, which also known as hydroelectric power, introduced by *al- Ġazarī* since the 7<sup>th</sup> century AH/ 13<sup>th</sup> century AD, became the most widely utilized form of renewable and clean energy later in areas with heavy rainfall and with mountainous regions in the 21<sup>st</sup> century<sup>108</sup>.
- In the hand washing automaton device used to perform the ritual ablution, *al- Ġazarī* had presented another form of the humanoid automata, which had been mentioned before. In addition, *al- Ġazarī* had invented a new superb technique, known as « flush mechanism». It is worth mentioning that this technique is the core stone for modern flush toilets first known since the 10<sup>th</sup> century AH/ 16<sup>th</sup> century AD by the British Sir John Harington<sup>109</sup>.

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<sup>107</sup> WINFIELD 2012:112-130, BEN-ARI &MONDADA 2018:3-6.

<sup>108</sup> ALLERHAND 2020: 76–87.

<sup>109</sup> MCCLURE (ED.)1930: 1-58.

## VII. CONCLUSION

This research paper had adopted the assumption that automata mechanisms are not an invention of the West, undertaking the mission to prove that they are an outcome of the Islamic civilization. The main method was through the Arabic treatise of *Ibn al-Razzāz al- Ġazarī* dated back to the 7<sup>th</sup> century AH/ 13<sup>th</sup> century AD in mechanical engineering, known briefly as «*kitāb al-Ĥiyal*». Although the Muslim scientists had been influenced by their predecessors; they had a head start in practical application, which was missing in robotic sciences before.

The treatise of *Ibn al-Razzāz al- Ġazarī* included fifty devices; distributed into six categories. This research paper had focused on only four automata mechanisms, recently simulated in diverse types and categories of industry, these are;

- A musical robotic band on a boat during drinking parties, which was an inspiration for a musical robot live-coding system bearing *al- Ġazarī's* name.
- A pitcher for wine, recently simulated by automated mechanisms for drinks.
- A peacock basin for washing hands, simulated by recent and contemporary robotic mechanisms for washing hands.
- A hand washing automaton with flush mechanism to perform the ritual ablution.

This had been recently the core stone for modern flush toilets.

Devices of *al- Ġazarī*, his detailed description on how they work, and the attached illustrations testify that automaton was not an innovation from the Western civilization. They are with no doubt a considerable achievement of Muslim civilization. Thus, the work of *al- Ġazarī* deserves to be described as the senior real study in systematic machinery design. In addition, he owed the title of 'the father of robotics'.

Conclusively, by virtue of the Muslim engineer *al- Ġazarī* modern technology had superbly improved. Robotics became a key technology employed in assembling cars, in moving goods, in washing machines, etc. Furthermore, robotics became of a higher value when, recently, employed in health care in case of infectious diseases as what happened in China to face Coronavirus pandemic widely known as Covid-19.

## HOW TO CITE

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# BIBLIOGRAPHY

- AL-ANDALŪSĪ (ŠĀ'ID IBN AḤMAD died 462 AH/ 1069-1070 AD): *Ṭabaqāt al-ʿUmmān*, Beirut (al-Maṭba'a al-Kathūlīkiyah lilābāa al-Yasū'in) 1912.
- AL-BĀSHĀ, H.: *Al-Taswīr al-Islāmī fī al-ʿuṣūr al-Wuṣṭā*, Cairo (maktabat al-Nahḍa al-Maṣrīyah) 1959.
- AL-FAIRŪZ ABADĪ (MAJD EL-DĪN MŪHAMMAD IBN YA'QŪP, died 817 AH): *Al-Qamūs al-Mūḥīṭ*, a revised copy, Cairo (Dar al-Ḥadīth) 2008. <https://www.noor-book.com/كتاب-القاموس-المحيط-ط-الحديث-pdf>
- AL-ĠAZARĪ (ABU AL-ʿIZZ IBN ISMA'IL IBN AR-RAZZĀZ): *Kitāb Fī Ma'rifat Al-Ḥiyāl Al-Handasiyya*, Aḥmad III N°. 3472 preserved in Top kapi in Istanbul, (microfilmed by the institute of Arabian scientific heritage- Hallab University registered under N°. 1739) 1206. [https://archive.org/details/midoghust\\_gmail\\_201701/page/n3/mode/2up](https://archive.org/details/midoghust_gmail_201701/page/n3/mode/2up).
- . *Kitāb Fī Ma'rifat Al-Ḥiyāl Al-Handasiyya*, Top Kapi Sarai Istanbul, (manuscript bookcase N°. 414) 1273. [https://www.alukah.net/manu/files/manuscript\\_331/2196.pdf](https://www.alukah.net/manu/files/manuscript_331/2196.pdf).
- . *Kitāb Fī Ma'rifat Al-Ḥiyāl Al-Handasiyya*, gallica.bnf.fr, 1485. <https://gallica.bnf.fr/ark:/12148/btv1b8406177t/f2.image>
- AL-ĠAZARĪ, I. & HILL, D.: *The Book of Knowledge of Ingenious Mechanical Devices = Kitāb Fī Ma'rifat Al-Ḥiyāl Al-Handasiyya*, Dordrecht, Holland (D. Reidel Publishing Co.) 1974.
- AL-ĠAZARĪ, I.: *Al-Jāmi Bain Al-Ilm Wal-Amal Al-Nāfi Fī Sinā at Al-Ḥiyāl: Compendium on the Theory and Practice of the Mechanical Arts*, Edited by AḤMAD YŪSŪF AL-ḤASSAN. Aleppo (Institute for The History of Arabic Science - University of Aleppo) 1979.
- AL-HASSAN, A. & HILL, D.: *Islamic Technology: An Illustrated History*, Cambridge: Paris (Cambridge University Press) 1986.
- AL-HASSAN, A.: Transfer of Islamic Science to the West, In: «*Cultural Contacts in Building a Universal Civilization: Islamic Contributions*», Istanbul: Research Centre for Islamic History, Art and Culture, IRCICA, 2005, 1–30.
- ALLERHAND, A.: Hydroelectric Power: The First 30 Years [History], «*IEEE Power and Energy Magazines*», 18/ 5, 2020, 76–87.
- AN-NADĪM (MŪHAMMAD IBN ISHĀQ), *Kitāb Al-Fihrist* 377 A.H/998 A.D, Edited by AYMAN FU'AD SAYYID, Vol. 2, 2<sup>nd</sup> ed., London (Mu'assasat Al-Furqān Lil-Turaṭh Al-Islāmī, Markaz Dirāṣat Al-Mkhtūṭāt Al-Islāmīyah) 1435 AH/2014 AD.
- BAHNASĪ, Š.: *Fann Al-Taṣwīr Fī Al-ʿaṣr Al-Islāmī*, Vol. 2, Alexandria (Dār Al-Wafā' Li-Dunyā Al-Ṭibā'ah Wa-Al-Nashr) 1986.
- BARASCH, F. K.: *The Grotesque: A Study in Meanings*, New York (The Hague: Mouton) 1971.
- BEDINI, S. & MADDISON, F.: Mechanical Universe: The Astrarium of Giovanni de' Dondi, «*Transactions of the American Philosophical Society*», 56/5, 1966.
- BEN-ARI M. & MONDADA F.: Robots and Their Applications. In: «*Elements of Robotics*», (Springer, Cham) 2018.
- BERRYMAN, S.: Ancient Automata and Mechanical Explanation, In: «*Phronesis*» 48/4, 2003, 344–69 <https://doi.org/10.1163/156852803772456083>.
- BROCKELMANN, C.: *Geschichte der arabischen Litteratur*, Vol. 1, Leiden (E.J. Brill) 1936.
- CECCARELLI, M. & CIGOLA, M.: Marcus Vitruvius Pollio. In: «*Distinguished Figures in Mechanism and Machine Science: Their Contributions and Legacies*», Part 3, Edited by MARCO CECCARELLI, Netherlands (Dordrecht Springer) 2014, 309-346.
- CHAPUIS, A. & DROZ, E.: *Automata; a Historical and Technological Study*, New York (Central Book Co.) 1958.
- CIGOLA, M., & GALLOZZI, A.: Drawings of Automatas in Middle Age: In «*International Symposium on History of Machines and Mechanisms*», 2000, 335–40.
- COOMARASWAMY, A. K.: *The Treatise of Al-Jazari on Automata; Leaves from a Manuscript of the Kitāb Fī Ma'rifat Al-Ḥiyāl Al-Handasiyya in the Museum of Fine Arts, Boston and Elsewhere*, Boston [s.n] 1924.
- DE SOLLA PRICE, D.: Automata and the Origins of Mechanism and Mechanistic Philosophy, In: «*Technology and Culture*» 5/1, 1964, 9–23. <https://doi.org/10.2307/3101119>.
- DE SOLLA PRICE, D., & HILL, D.: The Book of Knowledge of Ingenious Mechanical Devices by Ibn Al-Razzaz Al-Jazari, In: «*Technology and Culture*» 16/ 1, 1975, 81–83. <https://doi.org/10.2307/3102370>.



**CONTRIBUTIONS OF MUSLIM MECHANICAL ENGINEERS IN MODERN AUTOMATA  
(IN LIGHT OF KITĀB AL-ĤĪYAL OF AL- ĠAZARĪ) A DESCRIPTIVE ANALYTICAL STUDY**

- DEVECKA, M.: DID THE GREEKS BELIEVE IN THEIR ROBOTS?, In: «*The Cambridge Classical Journal*» 59, 2013, 52–69. <https://doi.org/10.1017/s1750270513000079>
- DIMAROGONAS, A.: *Machine Design: A CAD Approach*. Applied Mechanics Reviews, New York (Wiley-IEEE), 2001. <https://doi.org/10.1115/1.1383679>.
- DRACHMANN, A.: Ktesibios Philon and Heron. A Study in Ancient Pneumatics, In: «*Acta Historica Scientiarum Naturalium Et Medicinalium*», Bibliotheca Universitatis Hauniensis, Copenhagen 42/1, 1948. <https://doi.org/10.1086/349247>.
- FARAGO, C. J.: *Biography and Early Art Criticism of Leonardo Da Vinci*, New York, London (Garland) 1999.
- FARGHALĪ, A.: *Al-Taṣwīr Al-Islāmī*, Cairo (ad-Ḍār al-Libnānīah) 1991.
- FOWLER, R.: Roman Homer, In: «*The Cambridge Companion to Homer*», Cambridge (Cambridge University Press) 2004.
- ḤASSAN, Z.: Madrasat Baghdad fī Al-Taṣwīr Al-Islāmī, «*Majalat Sūmar*», 11, vol.2, 1955, 16-19.
- HILL, D.: Medieval Arabic Mechanical Technology, In: «*The First International Symposium for the History of Arabic Science*» 2, Aleppo (Institute for the History of Arabic Science) 1978, 222–37.
- . *Islamic Science and Engineering*, Edinburgh (Edinburgh University Press) 1993.
- . Arabic Fine Technology and Its Influence on European Mechanical Engineering, In: «*The Arab Influence in Medieval Europe*», UK (Ithaca press) 1994, 25–43. <https://doi.org/10.1017/s095742390000206x>.
- HUFFMAN, C.: *Archyras of Tarentum: Pythagorean, Philosopher and Mathematician King*, Cambridge (Cambridge University Press) 2005.
- IBN AL-QIFṬĪ (JAMAL EL-DĪN), *Tārīkh al-Ḥukamā'* 233 A.H, Edited by JULIUS LIPPERT, Leipzig (Dieterich) 1903.
- IBN KHALAKĀN (ABI AL-'ABĀS SHAMS AL-DĪN AḤMAD 608-681 AH/ 1211-1282 AD) *Wafayāt al-a'ya'n wa-anbā' anba' al-zamān*, Edited by IHSAN 'ABAS, vol.5, Beirut (Dar Ṣadir) 1397 AH/1977 AD.
- IRBY-MASSIE, GEORGIA L. & KEYSER, P.: *Greek Science of the Hellenistic Era: A Sourcebook*, London; New York (Routledge) 2002.
- KHAZĀIE, M.: The Source and Religious Symbolism of the Arabesque in Medieval Islamic Art of Persia, In: «*Central Asiatic Journal*», vol. 49/ 1, 2005, 27–50.
- MCCLURE, N. (ed.): *The Letters and Epigrams of Sir John Harington: Together with the Prayse of Private Life*, Philadelphia (University of Pennsylvania Press) 1930.
- NOCKS, L.: *The Robot: The Life Story of a Technology*, Westport, Conn.; London (Greenwood Press) 2007.
- ÖREN, T.: Advances in Computer and Information Sciences: From Abacus to Holonic Agents, In: «*Special Issue on Artificial Intelligence of Elektrik*, Turkish Journal of Electrical Engineering and Computer Sciences» 9/1, 2001, 63–70. <https://journals.tubitak.gov.tr/elektrik/issues/elk-01-9-1/elk-9-1-5-0010-3.pdf>.
- PATTERSON, O.: *Slavery and Social Death: A Comparative Study*, Cambridge, Mass. (Harvard University Press) 1982.
- RĀSHID, R.: *Les Mathématiques Infinitésimales Du IX<sup>e</sup> Au XI<sup>e</sup> Siècle*, London (Al-Furqān Islamic Heritage Foundation) 1996.
- REEVES, N.: A Rare Mechanical Figure from Ancient Egypt, In: «*Metropolitan Museum Journal*» 50, 2015, 42–61. <https://doi.org/10.1086/685672>.
- RIEFSTAHL, R. M.: The Date and Provenance of the Automata Miniatures, In: «*The Art Bulletin*» 11/2, 1929, 206–215. <https://doi.org/10.2307/3045443>.
- ROMDHANE, L. & ZEGHLOUL. S.: Al-Jazari (1136-1206), In: «*Distinguished Figures in Mechanism and Machine Science, Their Contributions and Legacies*», Edited by MARCO CECCARELLI, 1<sup>st</sup> ed., Vol. 2. Dordrecht: (Springer Netherlands) 2010. <https://doi.org/10.1007/978-90-481-2346-9>.
- ROSHEIM, M.: *Leonardo's Lost Robots*, Berlin (Springer-Verlag) 2016.
- SABINI, J. & KEEN. P.: *The World of Islam: Its Festival*, Vol. 27/3. New York (Saudi Aramco) 1976. <https://archive.aramcoworld.com/issue/197603/the.world.of.islam-its.festival.htm>.
- SALIBA, G.: *Islamic Science and the Making of the European Renaissance*, Cambridge, Mass. (Mit Press) 2007. <https://doi.org/10.1017/S000708740800160X>.
- SARTON, G.: *Introduction to the History of Science*, Vol.1, Baltimore (Williams & Wilkins), 1927.
- . *Introduction to the History of Science*, Vol.2/ 2. London: Huntington (NY Krieger Publishing Co) 1975.

- SCHARFF, A.: *Grundzüge Der Aegyptischen Vorgeschichte*, Leipzig (J. C. Hinrichs'sche Buchhandlung) 1927.
- SEZGIN, F.: *Geschichte Des Arabischen Schrifttums, Band V: Mathematik. Bis ca. 430 H*, Institut Für Geschichte Der Arabisch-Islamischen Wissenschaften An Der Johann Wolfgang Goethe-Universität, Leiden (E. J Brill) 1974.
- \_\_\_\_\_. *Geschichte Des Arabischen Schrifttums, Band VII, Astrologie, Metereologie Und Verwandtes Bis ca. 430H.*, Leiden (E.J. Brill) 1979.
- \_\_\_\_\_. *Banū Muṣā ibn Shākir (3<sup>rd</sup>/ 9<sup>th</sup> cent.) - Texts and Studies*, in collaboration with CARL EHRIG-EGGERT & AL., 1<sup>st</sup> ed., vol. 40, Institute for The History of Arabic-Islamic Science at The Johann Wolfgang Goethe University, Frankfurt (Frankfurt am Main) 2001.
- \_\_\_\_\_. *The Banū Muṣā and Thābit ibn Qurra: Their Works in Western Translation and Adaptations*, in collaboration with CARL EHRIG-EGGERT & AL., 1<sup>st</sup> ed., vol. 42, Institute for the History of Arabic-Islamic Science at the Johann Wolfgang Goethe University, Frankfurt (Frankfurt am Main) 2006.
- SHAMPO, M. A. & ROBERT, A. K.: Albertus Magnus—Doctor Universalis, In: «*Mayo Clinic Proceedings*», 60/8, 1985, 530. [https://doi.org/10.1016/S0025-6196\(12\)60570-9](https://doi.org/10.1016/S0025-6196(12)60570-9)
- SINGER, C., & AL.: *A History of Technology*, Vol. 2. Oxford (Oxford University press) 1979.
- THEISSEN H. & MURRENHOF, H.: Hydraulic System Basics, In: «*Mang T. (eds.) Encyclopedia of Lubricants and Lubrication*». Springer, Berlin (Heidelberg) 2014. [https://doi.org/10.1007/978-3-642-22647-2\\_149](https://doi.org/10.1007/978-3-642-22647-2_149)
- ‘ŪKĀSHAH, TH.: *Al-Taṣwīr Al-Islāmī Al-Dīnī*, Cairo (al-Mūassasah al-‘Arabiyya llnashr) 1990.
- ‘ŪMAR, M.: *Fihris Al-Makhṭūṭāt Al-Muṣawwarah Fī Maktabat Ma ‘had Al-Turāth Al-‘Ilmī Al-‘Arabī (Mulḥaq)*, Syria, Aleppo (Hallab University) 1986.
- UNGERER, A.: *Les Horloges Astronomiques et Monumentales Les plus Remarquables de l’antiquité à Nos Jours*, Strasbourg, (Chez L’auteur) 1931.
- WHITE, A. T., & AL. *The Golden Treasury of Myths and Legends: Adapted from the World’s Great Classics*. New York (Golden Press) 1959.
- WIEDEMANN, E.: Zur Mechanik und Technik bei der Arabern, In: «*Sitzungsberichte der Physikalisch-medizinischen Sozietät in Erlangen*», 38, Germany (Forgotten Books) 1906, 6–8.
- WILSON, A.: Machines in Greek and Roman Technology, In: «*The Oxford Handbook of Engineering and Technology in the Classical World*», edited by JOHN PETER OLESON, New York (Oxford University Press), 2008, 337–368.
- WINFIELD, A.: *Robotics: A Very Short Introduction*, USA (Oxford University Press), 2012.

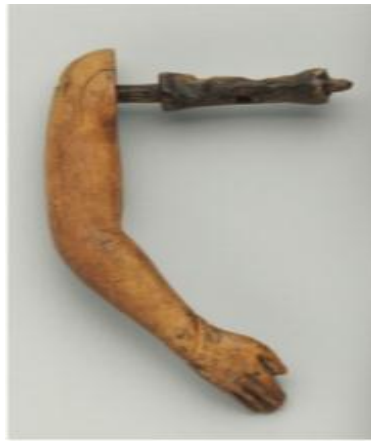
#### WEBSITES

- <https://hvr.dart.o/216544> Accessed: 17-10-2020.
- <https://www.clevelandart.org/art/1945.383> Accessed: 20-10- 2020.
- [www.jstor.org/stable/41928375](http://www.jstor.org/stable/41928375) Accessed: 03-11-2020.
- <http://www.jstor.org/stable/j.ctv512tgp> Accessed: 20-12- 2020.
- <https://www.noor-book.com/كتاب-القاموس-المحيط-ط-الحديث-pdf> Accessed: 02-01-2021.
- [https://archive.org/details/midoghust\\_gmail\\_201701/page/n3/mode/2up](https://archive.org/details/midoghust_gmail_201701/page/n3/mode/2up) Accessed: 05-11-2020.
- <https://archive.aramcoworld.com/issue/197603/the.world.of.islam-its.festival.htm> Accessed: 05-11-2020.
- <https://gallica.bnf.fr/ark:/12148/btv1b8406177t/f2.image> Accessed: 02-11-2019.
- <https://journals.tubitak.gov.tr/elektrik/issues/elk-01-9-1/elk-9-1-5-0010-3.pdf> Accessed: 18-10-2019.
- [https://www.alukah.net/manu/files/manuscript\\_331/2196.pdf](https://www.alukah.net/manu/files/manuscript_331/2196.pdf) Accessed: 11-03-2020.
- [https://www.si.edu/object/folio-kitāb-fi-maʿarifāt-al-hiyāl-al-handisāya-book-knowledge-ingenious-mechanical-devices-automata%3Afsg\\_F1930.73](https://www.si.edu/object/folio-kitāb-fi-maʿarifāt-al-hiyāl-al-handisāya-book-knowledge-ingenious-mechanical-devices-automata%3Afsg_F1930.73) Accessed: 21- 10- 2020.
- [https://link.springer.com/referenceworkentry/10.1007/978-3-642-22647-2\\_149#howtocite](https://link.springer.com/referenceworkentry/10.1007/978-3-642-22647-2_149#howtocite) Accessed: 04-12-2019.

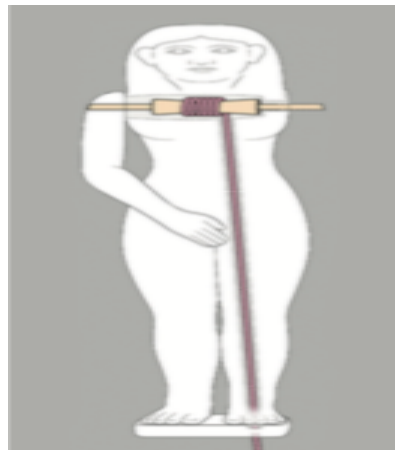
FIGURES



[FIGURE 1]: Female figure with internal mechanism. Egyptian, ca. 945–664 BC. Wood,  
The Metropolitan Museum of Art,  
REEVES 2015: [FIGURE 1]



[FIGURE 2]: Female figure's right arm and the axle attached  
REEVES 2015: [FIGURE 4]



[FIGURE 3]: Diagram of figure1, Showing the operating mechanism  
(axle in beige, string in pink)  
REEVES 2015: [FIGURE 6]

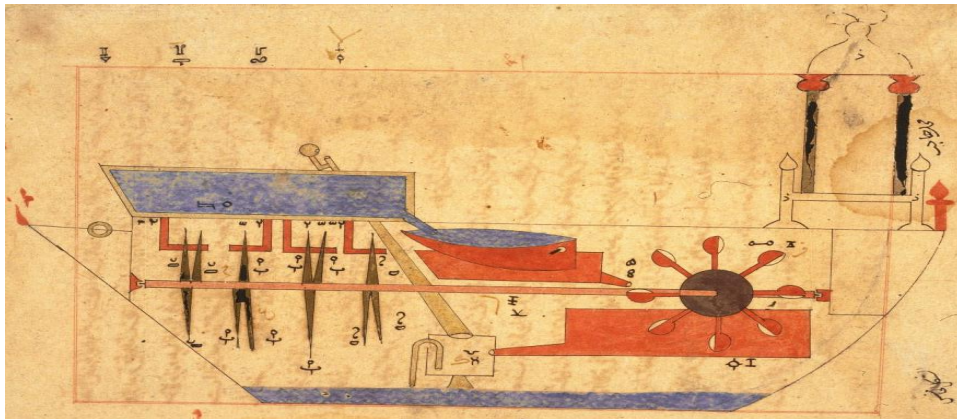


[FIGURE 4]: A wooden decked over boat. With a platform for the automated musical band

AL- ĠAZARĪ 1315: folio. [n.k] *Verso*

Smithsonian Gallery, Freer Gallery of Art and Arthur M. Sackler Gallery

[https://www.si.edu/object/folio-kitāb-fi-maārifat-al-hiyāl-al-handisāya-book-knowledge-ingenious-mechanical-devices-automata%3Aafsg\\_F1930.73](https://www.si.edu/object/folio-kitāb-fi-maārifat-al-hiyāl-al-handisāya-book-knowledge-ingenious-mechanical-devices-automata%3Aafsg_F1930.73) Accessed 21- 10- 2020



[FIGURE 5]: The automated musical band's boat; only displaying the boat and its mechanical functioning

AL- ĠAZARĪ 1206: Folio. 71. *Verso*



[FIGURE 6]: The cam mechanism

AL- ĠAZARĪ 1485: *Folio. 14*





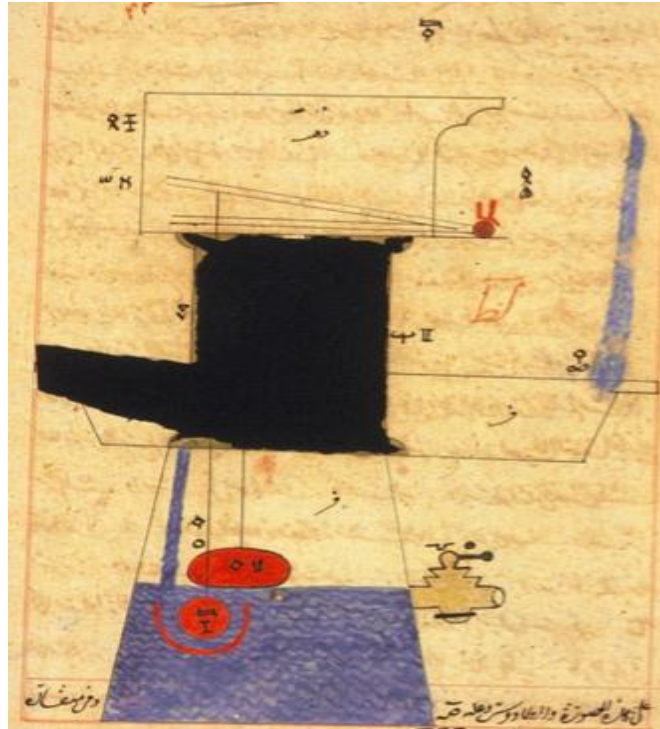
[FIGURE 7]: Illustration for A pitcher of wine  
AL- ĠAZARĪ 1354: Folio [n.k] recto

Harvard Art Museums/Arthur M. Sackler Museum, Bequest of Hervey E. Wetzel object  
number.1919.138 <https://hvr.dartmouth.edu/object/216544> Accessed 17-10- 2020



[FIGURE 8]: A peacock basin for washing hands  
AL- ĠAZARĪ 1315: Folio [n.k] recto

<https://www.clevelandart.org/art/1945.383> Accessed 20-10- 2020



[FIGURE 9]: A miniature for the peacock basin showing the float, the side tap, and the whole mechanism of the basin

AL- ĠAZARĪ 1206: Folio 99 Verso



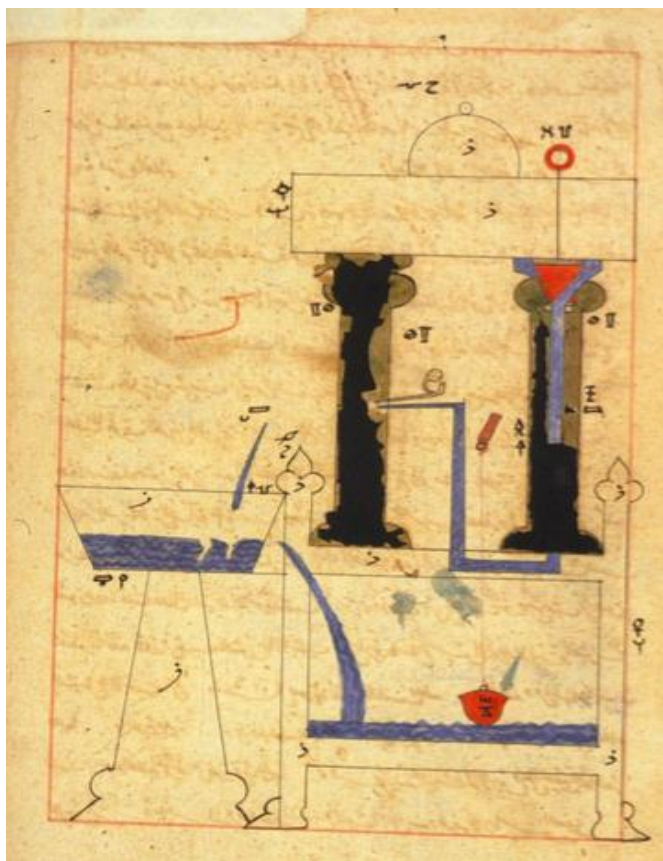
[FIGURE 10]: A miniature for the mechanism of the hand washing automaton

AL- ĠAZARĪ 1315: Folio [n.k] recto

Smithsonian Gallery, Freer Gallery of Art and Arthur M. Sackler Gallery

[https://www.si.edu/object/folio-kitāb-fi-ma-arifat-al-hiyal-al-handisaya-book-knowledge-ingenuous-mechanical-devices-automata%3Afsg\\_F1930.75](https://www.si.edu/object/folio-kitāb-fi-ma-arifat-al-hiyal-al-handisaya-book-knowledge-ingenuous-mechanical-devices-automata%3Afsg_F1930.75) Accessed 21- 10- 2020





[FIGURE 11]: A miniature for the mechanism of the hand washing automaton  
AL- ĠAZARĪ 1206: *Folio 101 Verso*

## إسهامات الهندسة الميكانيكية الإسلامية في تطوير الآلات ذاتية الحركة

(في ضوء كتاب الحيل للجزري)

دراسة وصفية تحليلية

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### الملخص

هل كان للعرب المسلمين قديماً باع في علم الهندسة الميكانيكية؟ وهل كان لهم سبق على الغرب في هذا المجال؟ من الملاحظ حالياً أن العرب والمسلمين في شتى دول العالم -تقريباً- أصبحوا مجرد مستهلكون لما ينتجه الغرب في شتى المجالات، نتيجة لما وصل إليه الغرب من تقدم وتطور تكنولوجي مستمر ومتنامي بسرعة فائقة. وهنا كان لابد لنا أن نتساءل هل كان العرب المسلمين على هذا الحال قديماً؟ يقوم هذا البحث على إثبات فرضية أن العلماء المسلمين قد حققوا تقدماً كبيراً في مجال الهندسة الميكانيكية، واستطاعوا ابتكار آلات ذاتية الحركة، والمعروفة حديثاً بـ «الأتمته». ووفقاً لذلك، كان الهدف الأساسي لهذا البحث هو إثبات صحة هذه الفرضية. يتناول هذا البحث بعض نماذج من الآلات ذاتية الحركة؛ وذلك من خلال كتاب «الجامع بين العلم والعمل النافع في معرفة الحيل الهندسية» لمؤلفه العالم المسلم الجزري. تضمن الكتاب - في الأصل مخطوط - وصف تفصيلي لهذه الآلات الميكانيكية ذاتية الحركة، وكيفية تنفيذها مشفوعاً بالتصاوير الملونة المعروفة اصطلاحاً بـ «المنمنمات». تتكون خطة البحث من تمهيد يتناول التعريف بما يصطلح عليه التكنولوجيا الدقيقة والأتمته «الآلات ذاتية الحركة»، ويلى ذلك تاريخ الأتمته بدءاً من العصور القديمة وحتى العصور الوسطى. كما سيتناول البحث إسهامات علماء المسلمين في مجال الهندسة الميكانيكية بشكل عام، وفي مجال إنتاج الآلات ذاتية الحركة بشكل خاص، مدعوماً باستعراض نماذج للآلات ذاتية الحركة تم شرحها ضمن «كتاب الحيل». ويلى ذلك السيرة الذاتية للعالم المسلم اسماعيل بن الرزاز الملقب بـ «الجزري»، بالإضافة إلى تحليل تاريخي وفني موجز عن المخطوط محل الدراسة. وفي النهاية سيتم عمل دراسة تحليلية للنماذج المختارة من الآلات ذاتية الحركة وعلاقتهم بالآلات الحديثة والصناعات التكنولوجية المتطورة. وفي المجلد واستناداً على «كتاب الحيل»، والذي يعود تاريخه للقرن ١٣هـ / ١٣م تمكن هذا البحث من التدليل على أن الآلات ذاتية الحركة ليست اختراعاً غريباً؛ بل هي نتاج الحضارة الإسلامية، ودليل ملموس على مدى تفوقهم في مجال الهندسة الميكانيكية منذ العصور الوسطى.

**الكلمات الدالة:** الهندسة الميكانيكية، الأتمته، المنمنمات، مخطوط، الحضارة الإسلامية، الجزري، كتاب الحيل.